NATIONAL HURRICANE CENTER ANNUAL SUMMARY

2012 ATLANTIC HURRICANE SEASON

Stacy Stewart

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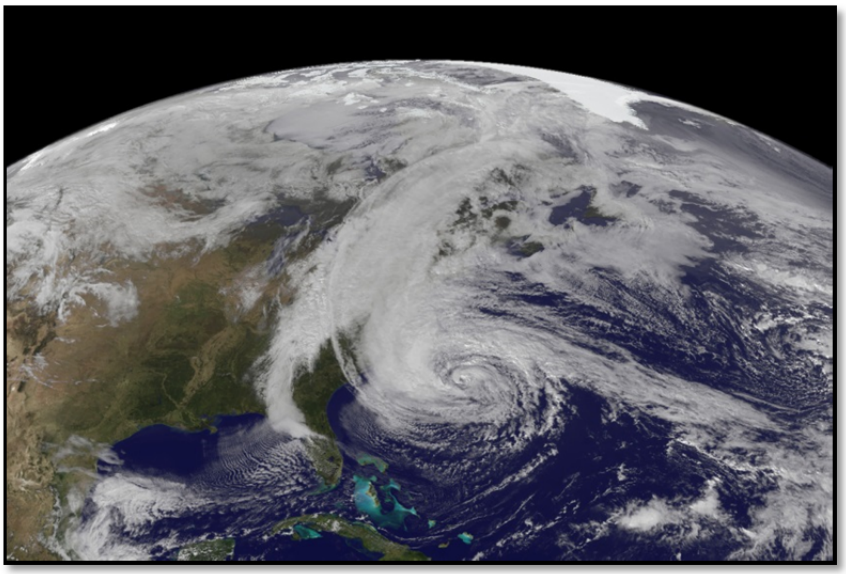

GOES-13 IMAGE OF HURRICANE SANDY AT 1745 UTC 28 OCTOBER 2012.

ABSTRACT

The 2012 Atlantic hurricane season was marked by above-average tropical cyclone activity with the formation of 19 tropical storms, of which 10 became hurricanes. Two of the hurricanes (Michael and Sandy) were category 3 or higher on the Saffir-Simpson Hurricane Wind Scale. The numbers of tropical storms and hurricanes were each above the long-term (1981 – 2010) averages of 12 and 6, respectively. The two major hurricanes were slightly below the long-term average of three, and they collectively only lasted for a total of 12 h at that strength. Six of the storms made landfall and five of the named cyclones had non-tropical origins. The land areas most affected were the United States, eastern Mexico, and the nations of the western Caribbean Sea. In addition, one hurricane (Leslie) became post-tropical just before it struck Newfoundland in eastern Canada. Despite the high level of activity, only one hurricane officially made landfall in the United States in 2012. The death toll from the 2012 Atlantic tropical cyclones was 195.

OVERVIEW

The 2012 Atlantic hurricane season was marked by above-average tropical cyclone activity with the formation of 19 tropical storms, of which 10 became hurricanes. Two of the hurricanes (Michael and Sandy) strengthened into major hurricanes (Category 3 or higher on the Saffir-Simpson Hurricane Wind Scale). The numbers of tropical storms and hurricanes were each above the long-term (1981–2010) averages of 12 and 6, respectively. The two major hurricanes were slightly below the long-term average of three, and collectively they only lasted for a total of 12 hours. Six of the storms made landfall and five of the named cyclones had non-tropical origins. The season's cyclones are listed in Table 1, with the tracks shown in Figure 1.

Despite the above-average number of named storms, only one cyclone (Isaac) officially made landfall as a hurricane in the United States. Sandy also brought hurricane-force winds to the U.S. coast, but had become post-tropical by the time it made landfall. The majority of the tropical cyclones recurved away from North America and remained over the open Atlantic, a result of a mid-tropospheric trough that persisted over the eastern United States through the August-to-October peak tropical cyclone period (Figure 2). Damage in the United States due to the season's cyclones (including the post-tropical stage of Sandy) was more than $52 billion. Damage in other countries across the basin was also significant. In Mexico, Hurricane Ernesto made two landfalls — the first as a hurricane along the eastern coast of the Yucatan Peninsula near Cayo Norte and the second as a tropical storm along the mainland coast of Mexico near Coatzacoalcos — which resulted in seven direct deaths and five indirect deaths in the country. Although complete damage estimates in Mexico are not available, media reports indicate that Ernesto caused at least $174 million (USD) in damage, including $76.4 million (USD) in agricultural losses.

The 2012 hurricane season was the third consecutive one in which 19 named storms developed. The Accumulated Cyclone Energy (ACE) index was 144% of the long-term median, the eleventh-highest total in the last 30 years. This continued the recent trend of above-average Atlantic tropical cyclone activity, as well as the longer-term increase in activity that began in the late 1990's. Although a record eight named storms formed during the month of August, only one of those reached hurricane status within the Main Development Region (MDR).

Environmental and oceanic conditions were particularly conducive during the August-to-October peak development period across most of the tropical Atlantic MDR (Bell et al. 2013). Vertical wind shear was lower than average primarily due to an increase in 200-hPa easterly winds. Furthermore, sea-level pressures were average to below average, sea-surface temperatures were average to above average, and total precipitable water was above average. This combination of conditions would generally support tropical cyclone formation within the MDR, which did occur, as well as significant intensification, which did not occur until late in the season when Hurricane Sandy developed and intensified over the southwestern Caribbean Sea. One possible explanation for the limited development in the MDR was the presence of drier than average middle-tropospheric air associated with the Saharan Air Layer, which has been suggested as being an inhibitor to tropical cyclonegenesis and intensification (Dunion and Velden 2004).

In late October, Hurricane Sandy interacted with an intense deep-layer trough and associated strong upper-level warm air advection. These factors contributed to an extraordinary expansion of the cyclone's wind field, which led to record storm surge values across much of the mid-Atlantic and northeastern regions of the United States.

The following section highlights the most significant cyclones of the season. More detailed information on these storms, as well as information on the other tropical cyclones that formed in 2012, can be found at http://www.nhc.noaa.gov/2012atlan.shtml.

SELECTED STORM SUMMARIES

Hurricane Isaac

Isaac became a tropical depression on 21 August about 625 n mi east of the Lesser Antilles. The depression strengthened and became a tropical storm 12 h later, and then moved quickly westward for the next two days. The center of Isaac passed through the Leeward Islands between Guadeloupe and Dominica late on 22 August, and continued generally westward over the eastern Caribbean Sea for the next few days. Gradually strengthening as it turned northwestward toward Hispaniola, Isaac made landfall along the southern coast of Haiti near the city of Jacmel early on 25 August. The cyclone quickly traversed the southwestern peninsula of Haiti and weakened slightly before making landfall along the southeastern coast of Cuba near Cajobabo, Guantánamo later that day. The large tropical storm moved across the Turks and Caicos Islands and most of the Bahamas before turning west-northwestward on 26 August, paralleling the northern coast of Cuba and passing south of the Florida Keys.

Isaac entered the southeastern Gulf of Mexico early on 27 August, and moved slowly toward the northwest, strengthening and growing in size while moving across the Gulf of Mexico. Isaac slowed down and became a hurricane on 28 August as it approached the mouth of the Mississippi River. An initial landfall occurred along the southeastern coast of Louisiana at Southwest Pass on the mouth of the Mississippi River early on 29 August, after which Isaac wobbled westward back over water (Fig. 3) and made a second landfall just west of Port Fourchon, Louisiana, around 0800 UTC 29 August. Gradual weakening ensued once Isaac moved inland over southeastern Louisiana, and it became a tropical storm later that day when it was located just west-southwest of New Orleans. Isaac turned northwestward across Louisiana on 30 August, and weakened to a tropical depression early on 31 August, shortly after it crossed into southern Arkansas. The depression turned northward and moved into southwestern Missouri late that day, and Isaac dissipated early on 1 September about 55 n mi west-southwest of Jefferson City, Missouri.

Isaac's extensive wind field caused widespread storm surge flooding along the northern coast of the Gulf of Mexico, especially in southeastern Louisiana, Mississippi, and Alabama. In addition, the cyclone produced heavy rainfall and inland flooding across Puerto Rico, Hispaniola, eastern Cuba, portions of southern and east-central Florida, and most of extreme

southwestern Alabama, southern Mississippi and southeastern Louisiana. Seventeen tornadoes occurred in the United States while Isaac was a tropical cyclone, and most were rated as EF-0 or EF-1. Isaac was directly responsible for 34 deaths: 24 in Haiti, 5 in the Dominican Republic, and 5 in the United States. The total damage in the United States is estimated to be $2.35 billion, and about $8 million (US) in Haiti.

Hurricane Sandy

Sandy, the season's most damaging (and meteorologically complex) cyclone, became a tropical depression over the southwestern Caribbean Sea on 22 October, strengthened into a tropical storm 6 h later, and reached hurricane strength on 24 October south of Kingston, Jamaica. The hurricane continued to intensify and reached the southeastern coast of Jamaica later that day with maximum winds of 75 kt. Despite its brief passage over Jamaica, Sandy developed a well-defined eye (Fig. 4) and rapidly intensified. The cyclone briefly was at major hurricane strength, with maximum sustained winds of 100 kt (category 3) and an estimated central pressure of 954 mb, just before it made landfall over southeastern Cuba early on 25 October (Fig. 1). Sandy weakened over eastern Cuba, where it caused considerable damage, and emerged into the Atlantic Ocean south of Ragged Island in the southeastern Bahamas late that day.

Now a tropical storm, Sandy moved slowly northwestward and northward through the Bahamas and increased greatly in size. After passing the Bahamas, Sandy gradually turned northeastward ahead of an upper-level trough and regained hurricane strength on 27 October while its wind field continued to expand. Sandy passed southeast of North Carolina on 28 October (Fig. 5a), and by early on 29 October the hurricane turned northward and moved over warm Gulf Stream waters, which helped Sandy to strengthen further (Fig. 5b). Later that day, the hurricane turned northwestward and accelerated toward the eastern United States. Cold coastal shelf waters, interaction with frontal systems, and increasing vertical wind shear caused Sandy to weaken and lose its tropical characteristics. The large category 1 hurricane made the transition into a powerful extratropical cyclone by 2100 UTC 29 October, about 45 n mi southeast of Atlantic City (Fig. 1), and made landfall as a post-tropical cyclone at about 2330 UTC near Brigantine, New Jersey, just to the northeast of Atlantic City, with an estimated intensity of 70 kt and a central pressure of 945 mb.

After landfall, the post-tropical cyclone slowed down and moved west-northwestward, and gradually weakened as its center moved through southern New Jersey, northern Delaware and southern Pennsylvania. The center of the low became ill defined over northeastern Ohio on 31 October, and Sandy's remnants moved northward to northeastward over Ontario, Canada for the next day or two before merging with a low pressure area over eastern Canada.

Sandy's impacts in the United States were widespread. A catastrophic storm surge occurred along the New Jersey and New York coastlines, damaging or destroying at least 650,000 homes. Preliminary damage estimates are near $50 billion, making Sandy the second-costliest cyclone to hit the United States. Outside of the United States, damage estimates (all in USD) include $2 billion in Cuba (making Sandy one of the costliest hurricanes in Cuba's

history), $750 million in Haiti, about $100 million in Jamaica, and $30 million in the Dominican Republic. At least 147 direct deaths occurred across the Atlantic basin due to Sandy, with the mid-Atlantic and northeastern United States recording 72 of these fatalities. This is the greatest number of U.S. direct fatalities associated with a tropical cyclone outside of the southern states since Hurricane Agnes in 1972. At least 87 indirect deaths were also associated with Sandy or its remnants in the United States.

FORECAST VERIFICATION

The 2012 Atlantic hurricane season had above-normal activity, with 444 official forecasts issued. The mean NHC official track forecast errors in the Atlantic basin were lower than the previous 5-yr means at all times, and set records for accuracy at all forecast times except 120 h. The official track forecasts were very skillful and performed close to or better than the TVCA consensus model and the best-performing dynamical models. The FSSE had the highest skill and was the only guidance that consistently beat the official forecast. GFSI, AEMI, and EMXI were very good performers, with the HWFI and EGRI making up the second tier. The NGXI was the poorest-performing major dynamical model, and the CMCI and GHMI had similar skill to NGXI at 96 and 120 h.

Mean official intensity errors for the Atlantic basin in 2012 were below the 5-yr means at all lead times. Decay-SHIFOR errors in 2012 were also lower than their 5-yr means at all forecast times, indicating the season's storms were easier than normal to forecast. The consensus models ICON and FSSE were the best performers, and were the only models that had skill throughout most or all of the forecast period. The HWFI was a poor performer and had no skill throughout the entire period. National Hurricane Center model acronyms can be found at http://www.nhc.noaa.gov/modelsummary.shtml

An analysis of the 2012 quantitative probabilistic forecasts of tropical cyclogenesis (i.e., the likelihood of tropical cyclone formation from a particular disturbance within 48 h and expressed in 10% increments and in terms of categories "low", "medium", or "high") indicate that these probabilistic forecasts had a low or under-forecast bias.

REFERENCES

Bell, G. D., E. S. Blake, C. W. Landsea, T. B. Kimberlain, S. B. Goldenberg, J. Schemm, and R. J. Pasch, 2013: Tropical Cyclones - Atlantic Basin, State of the Climate in 2011. *Bulletin of the American Meteorological Society*, (in press).

Dunion, J.P., and C.S. Velden, 2004: The impact of the Saharan Air Layer on Atlantic tropical cyclone activity. Bull. Amer. Meteor. Soc., vol. 85 no. 3, 353-365.

Texas Tech University, 2006: A Recommendation for an Enhanced Fujita Scale. [Available online at http://www.depts.ttu.edu/weweb/EFScale.pdf].

Table 1. 2012 Atlantic hurricane season statistics.

Storm Name	Class[a]	Dates[b]	Max. Winds (kt)	Min. Pressure (mb)	Deaths	U.S. Damage ($million)
Alberto	TS	May 19 – 22	50	995		
Beryl	TS	May 26 – 30	60	992	1	
Chris	H	June 18 – 22	75	974		
Debby	TS	June 23 – 27	55	990	5	250
Ernesto	H	August 1 – 10	85	973	7	
Florence	TS	August 3 – 6	50	1002		
Gordon	H	August 15 – 20	95	965		
Helene	TS	August 9 – 18	40	1004		
Isaac	H	August 21 – September 1	70	965	34	2350
Joyce	TS	August 22 – 24	35	1006		
Kirk	H	August 28 – September 2	90	970		
Leslie	H	August 30 – September 11	70	968		
Michael	MH	September 3 – 11	100	964		
Nadine	H	September 10 – October 3	80	978		
Oscar	TS	October 3 – 5	45	994		
Patty	TS	October 11 – 13	40	1005		
Rafael	H	October 12 – 17	80	969	1	
Sandy	MH	October 22 – 29	100	940	147	50000
Tony	TS	October 22 – 25	45	1000		

[a] Tropical depression (TD), maximum sustained winds 33 kt or less; tropical storm (TS), winds 34-63 kt; hurricane (H), winds 64-95 kt; major hurricane (MH), winds 96 kt or higher.

[b] Dates begin at 0000 UTC and include all tropical and subtropical cyclone stages; non-tropical stages are excluded.

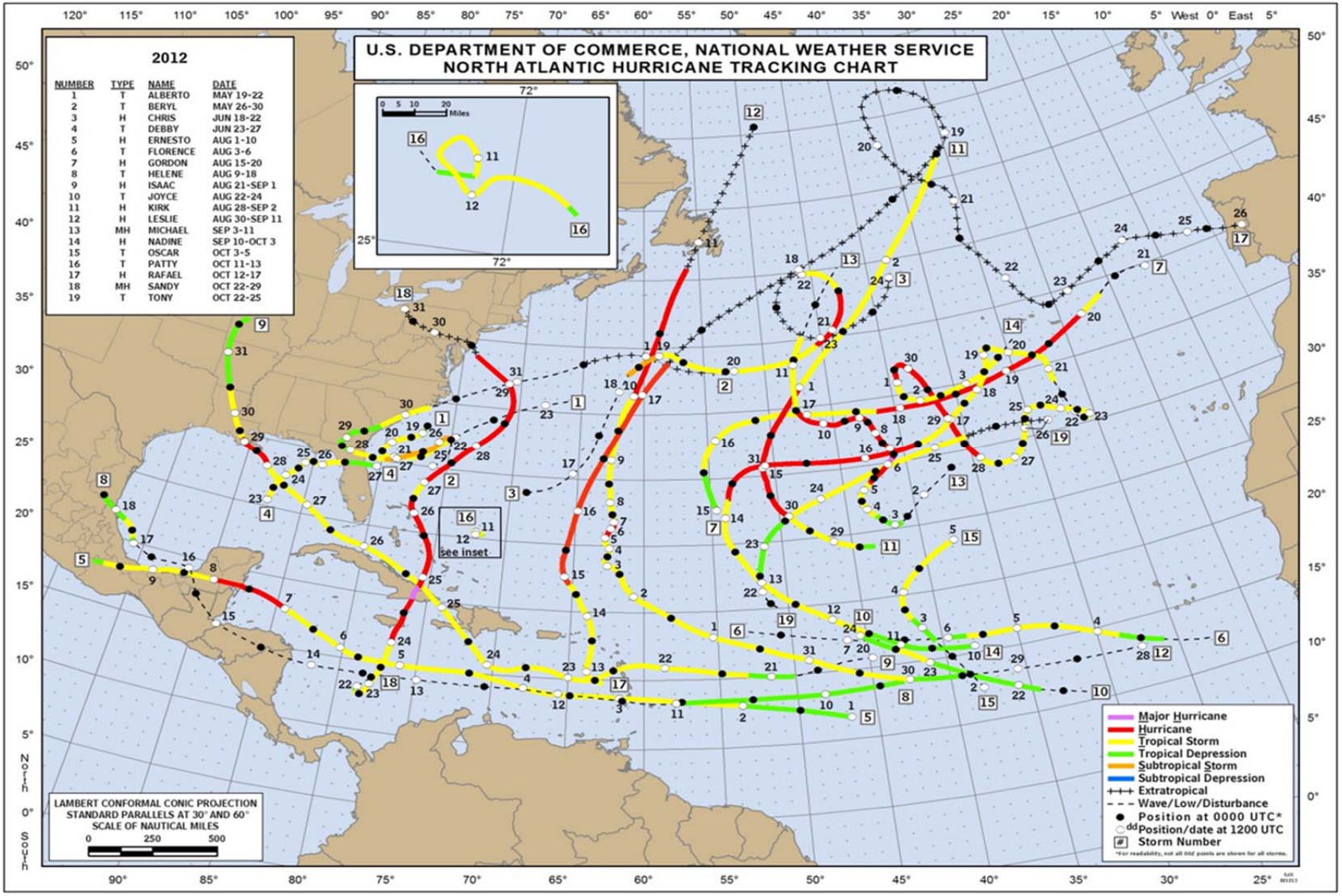

Figure 1. Tracks of Atlantic tropical storms and hurricanes during 2012.

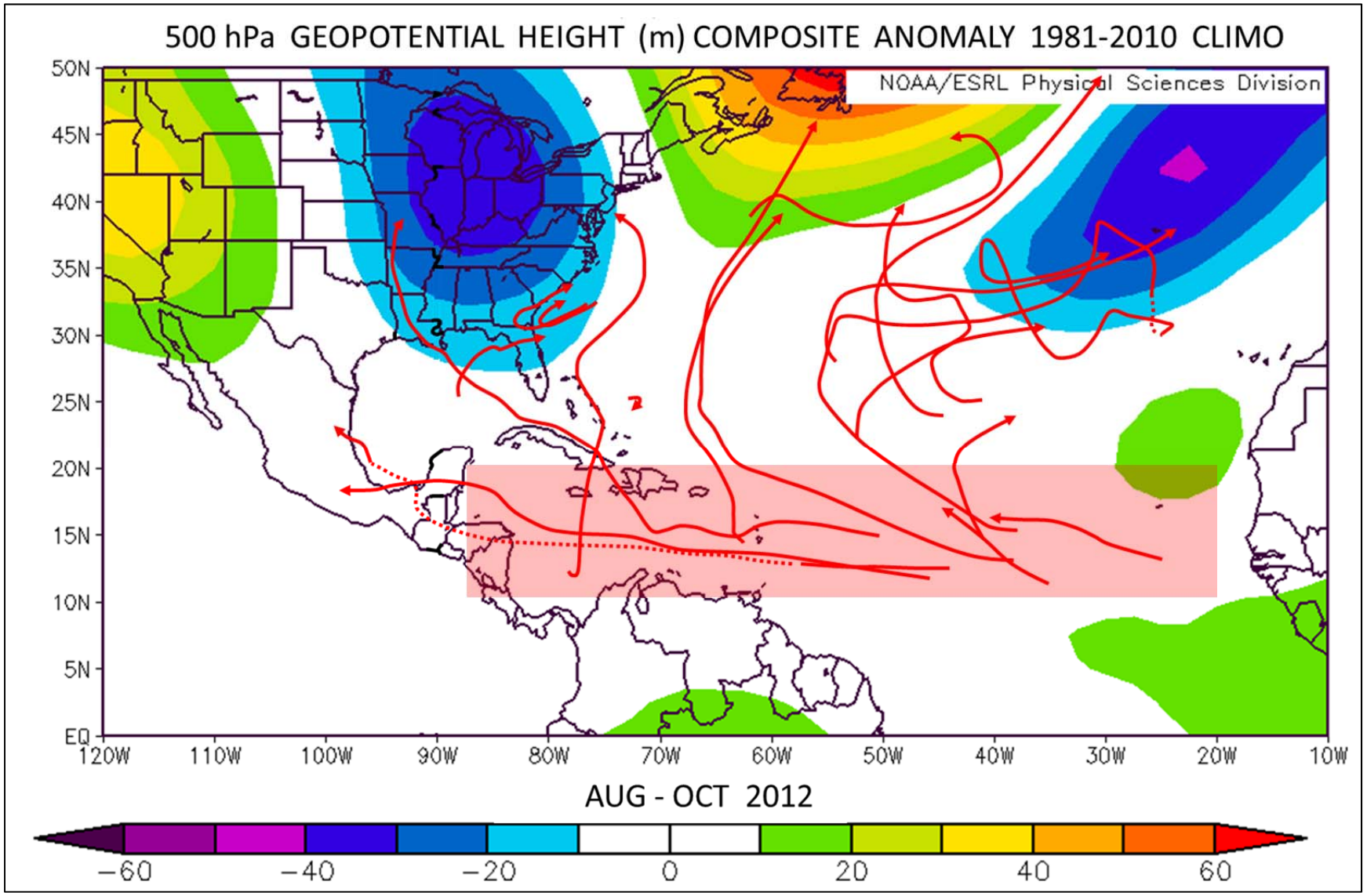

Figure 2. Atlantic tropical cyclone and hurricane tracks for 2012 superimposed onto August through October 2012 500-hPa height anomalies (m). The pink-shaded area is the Atlantic hurricane Main Development Region (MDR). Data is from the NCEP-NCAR re-analysis (CDAS) Project.

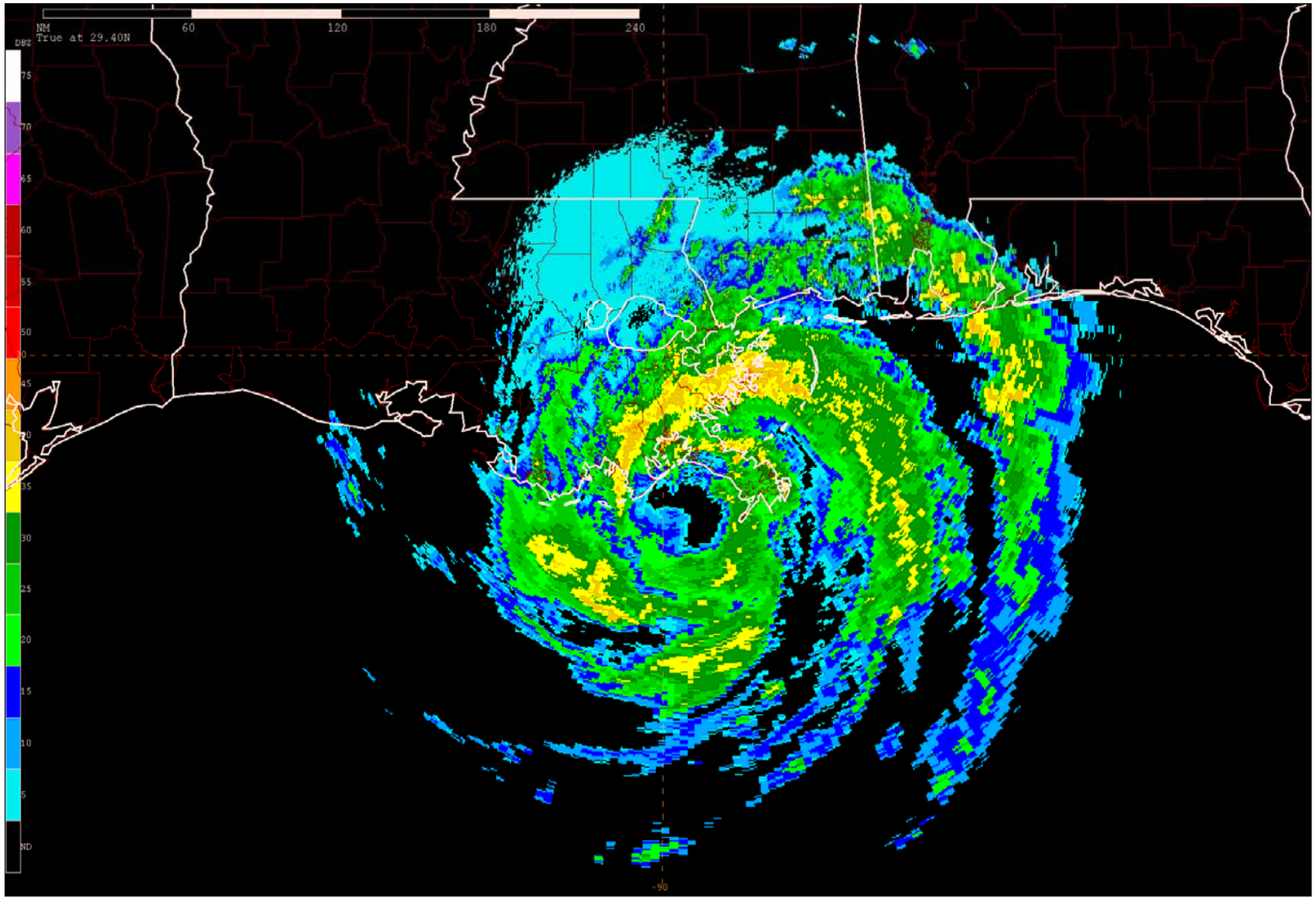

Figure 3. Low-level reflectivity image of Hurricane Isaac from the WSR-88D radar in Slidell, Louisiana, at 0304 UTC 29 August 2012 between its two landfalls along the coast of Louisiana. Isaac's minimum pressure of 965 mb occurred at about this time.

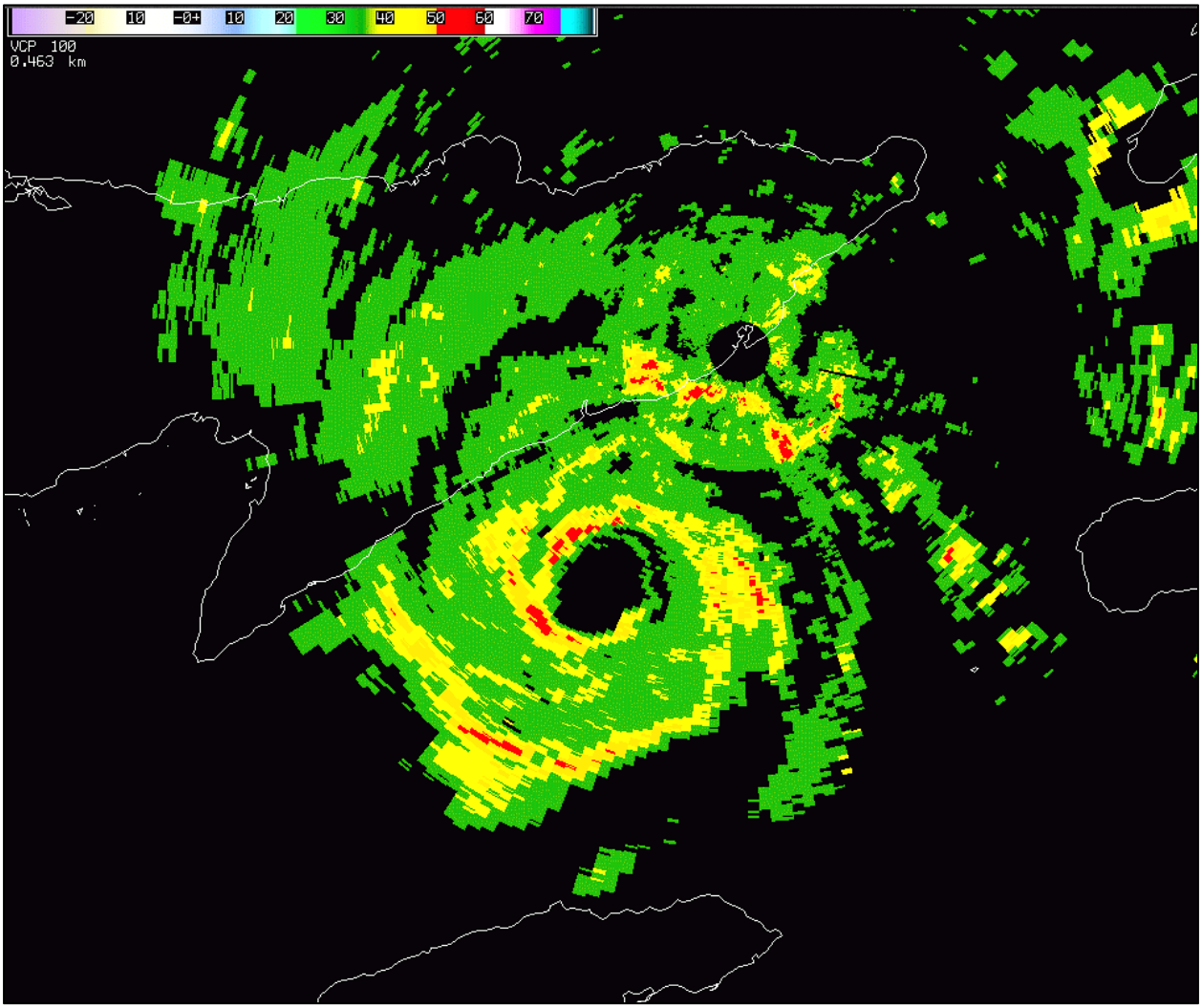

Figure 4. Guantánamo Bay Naval Base ARSR-4 FAA ATC Doppler radar reflectivity image showing the eye of Hurricane Sandy approaching Santiago de Cuba at 0332 UTC 25 October 2012.

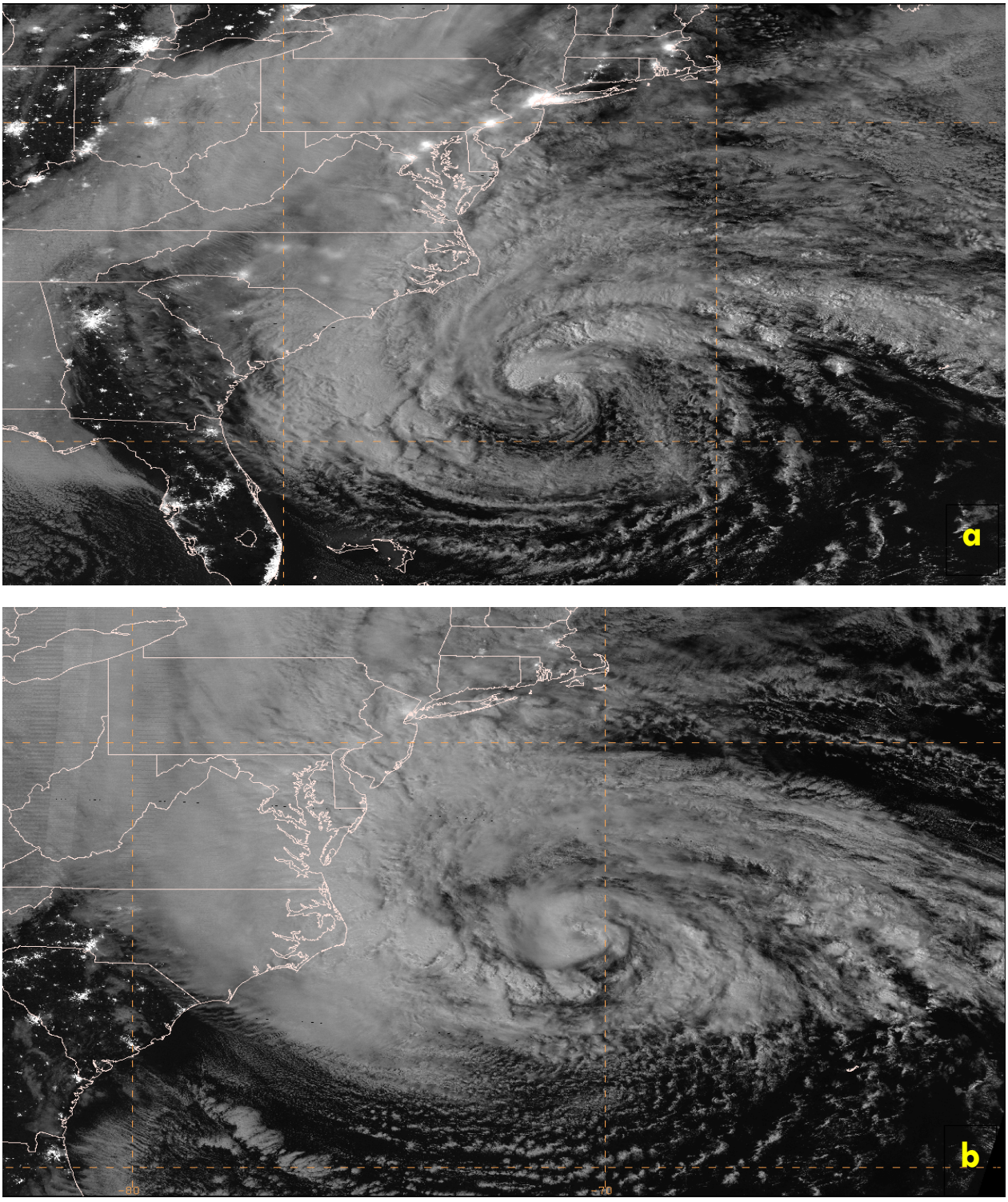

Figure 5. NOAA-NASA Suomi National Polar-orbiting Partnership (NPP) moonlight visible images of Hurricane Sandy at (a) 0625 UTC UTC 28 October 2012 and (b) 0606 UTC 29 October 2012.